TITLE OF THE INVENTION

APPARATUS FOR AND METHOD OF COLOR COMPENSATION

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Application No. 2002-44353, filed July 26, 2002 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to an apparatus for and a method of color compensation, and more particularly, to an apparatus for and a method of color compensation capable of color-compensating to a desired color when an expressed color is distorted when displayed on a displaying apparatus.

2. Description of the Prior Art

[0003] Oftentimes, color represented on a displaying apparatus is distorted during an image signal transmission or by the influence of external light used for camera photography. Especially when the color that is distorted is visually sensitive, such as the color of human skin (skin tone), the color needs to be compensated.

[0004] An apparatus for and a method of color compensation generally compensate for an input color to be as close as an original color in the event of color distortion. FIG. 1 is a view showing one example of a conventional method of color compensation, especially a method of compensating the skin tone. Referring to FIG. 1, a color preference axis A is set up. The color preference axis A is the reference used to compensate the skin tone, is set up. In FIG. 1,

the preference axis A is shown in a YUV color space. After setting up the preference axis A, mapping is performed in order to have color value of the preference axis A by moving color existing in a certain area (area with slant lines in FIG. 1) adjacent to the preference axis A to the preference axis A. As shown, the preference axis A has an angle of either 123° or 117°. An example of this method is used by a TDA9178 chip manufactured by Philips Semiconductor.

[0005] Another compensation method is to detect the area of the skin tone in an entire image first, and skip the color enhancement for the detected area. However, the above apparatus for and method of color compensation has a problem in that the result of the color compensation is visually unsatisfactory as it moves the color of a certain area to a color value of a set up preference axis A without considering a preference of people or which does not perform color enhancement with respect to a certain area such as the skin tone. Moreover, as the method only compensates for hue, it is not possible to properly compensate for a distortion of the chroma or luminance of the color.

SUMMARY OF THE INVENTION

[0006] It is an aspect of the present invention to provide an apparatus for and a method of color compensation capable of compensating chroma, hue and luminance based on a color preference of people when color displayed on a displaying apparatus is distorted.

[0007] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0008] The above and/or other aspects of the present invention can be realized by providing an apparatus for color compensation according to an aspect of the invention which includes a chroma deflection generation unit to calculate a chroma deflection based on an input chroma

signal and a predetermined first reference value, a hue deflection generation unit to calculate a hue deflection based on an input hue signal and a predetermined second reference value, a luminance deflection generation unit to calculate a luminance deflection based on an input luminance signal and a predetermined third value, and a skin tone mapping function generation unit to output a corrected chroma signal, a corrected hue signal, and a corrected luminance signal after individually compensating the input chroma, hue, and luminance signals based on the calculated chroma deflection, the calculated hue deflection and the calculated luminance deflection.

[0009] It is preferable, but not required, that the apparatus further comprises a color space conversion unit to convert a color signal of an input image in color space so as to calculate the input chroma signal, the input hue signal, and the input luminance, and to transmit the calculated chroma, hue, and luminance signals to the chroma deflection generation unit, the hue deflection generation unit and luminance deflection unit.

[0010] It is advisable, but not required, that the first, second and third reference values are provided based on empirical data collected after statistically processing data obtained through experiment.

[0011] It is recommended, but not required, that the chroma deflection is calculated based on a difference between the input chroma signal and the first reference value, and the skin tone mapping function unit outputs the corrected chroma signal compensated by summing the input chroma signal and the chroma deflection.

[0012] It is preferable, but not required, that the hue deflection is calculated based on a difference between the input hue signal and the second reference value, and the skin tone

mapping function unit outputs the corrected chroma signal compensated by summing the input hue signal and the hue deflection.

[0013] Moreover, it is advisable, but not required, that the luminance deflection is calculated based on a difference between the input luminance signal and the third reference value, and the skin tone mapping function unit outputs the corrected luminance signal compensated after summing the input luminance signal and the luminance deflection.

[0014] According to another aspect of the invention, a method of color compensation comprises calculating a chroma deflection based on an input chroma signal and a predetermined first reference value, calculating a hue deflection based on an input hue signal and a predetermined second reference value, calculating a luminance deflection based on an input luminance signal and a predetermined third reference value; and outputting a compensated chroma signal, a compensated hue signal, and a compensated luminance signal resulting after individually compensating the input chroma, hue, and luminance signals based on the chroma deflection, the hue deflection and the luminance deflection.

[0015] It is advisable, but not required, that the method further comprises converting a color signal of an input signal in color space to calculate the chroma signal, the hue signal, and the luminance signal, and individually transmitting the calculated chroma, hue, and luminance signals as the input signals for use in the calculating the chroma deflection, hue deflection, and the luminance deflection.

[0016] It is preferable, but not required, that the first, second and third reference values are provided based on empirical data collected after statistically processing data obtained through experiment.

[0017] It is advisable, but not required, that the chroma deflection is calculated based on a difference between the chroma signal and the first reference value, and the outputting the compensated chroma signal, hue signal, and the luminance signal the comprises summing the input chroma signal and the chroma deflection to output the compensated chroma signal.

[0018] It is recommended, but not required, that the hue deflection is calculated based on a difference between the input hue signal and the second reference value, and the outputting the compensated chroma signal, the hue signal, and the luminance signal comprises summing the input hue signal and the hue deflection to output the compensated hue signal.

[0019] It is preferable, but not required, that the luminance deflection is calculated based on a difference between the input luminance signal and the third reference value, and the outputting the compensated chroma signal, the hue signal, and the luminance signal comprises summing the input luminance signal and the luminance deflection to output the compensated luminance signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The above and/or other aspects and features of the present invention will be more apparent and more readily appreciated by describing the embodiments of the present invention by referring to the accompanying drawings, in which:

FIG. 1 shows a conventional method of color compensation;

FIG. 2 is a block diagram showing an apparatus for color compensation according to an embodiment of the present invention;

FIG. 3 is a flow chart showing an embodiment of an operation method of the apparatus for color compensation of FIG. 2;

FIGs. 4 and 5 are views showing the area of the skin tone preferred by people expressed in a YCbCr color space; and

FIG. 6 is a graph showing a color deflection function for calculating color deflection.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0021] Reference will now be made in detail to the present embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

[0022] FIG. 2 is a block diagram showing an apparatus for color compensation according to an embodiment of the present invention and which is capable of compensating the skin tone. Referring to FIG. 2, the apparatus includes a color space conversion unit 100, a chroma deflection function generation unit 110, a hue deflection function generation unit 120, a luminance deflection function generation unit 130, and a skin tone mapping function generation unit 140. The color space conversion unit 100 converts a color signal of an input image and outputs a hue signal, a chroma signal, and a luminance signal. The chroma deflection function generation unit 110 calculates a chroma deflection. The hue deflection function generation unit 120 calculates a hue deflection. In addition, the luminance deflection function generation unit 130 generates a luminance deflection. The skin tone mapping function generation unit 140 compensates the original chroma signal, the hue signal, and the luminance signal based on the calculated chroma deflection, hue deflection and luminance deflection.

[0023] FIG. 3 is a flow chart showing the operation method of the apparatus for color compensation of FIG. 2. Referring to FIG. 3, the color space conversion unit 100 calculates the original chroma signal, the original hue signal and the original luminance signal from the color

signal of the input image (S200). The color signal of the input image can have various color spaces such as RGB, YIQ, YUV, YCbCr and HLS in accordance with the environment. These color signals are converted into the original chroma signal, the original hue signal and the original luminance signal by using appropriate mathematical expressions.

[0024] The original chroma signal, the original hue signal and the original luminance signal calculated at the color space conversion unit 100 are individually transmitted to the chroma deflection function generation unit 110, the hue deflection function generation unit 120, and the luminance deflection function generation unit 130. The chroma deflection function generation unit 110 calculates the chroma deflection based on the transmitted chroma signal and a first reference value. The hue deflection function generation unit 120 calculates the hue deflection based on the transmitted hue signal and a second reference value. The luminance deflection function generation unit 130 calculates the luminance deflection based on the transmitted luminance signal and a third reference value (S210).

[0025] According to an embodiment of the invention, the first, second and third reference values used for calculating the chroma deflection, the hue deflection, and the luminance deflection are decided by the following method. In the case of the skin tone, the skin tone is classified in accordance with race. The chroma, the hue and the luminance are changed with respect to the skin tone for each race. The skin tone most preferred by a person is determined using experimental data. For the objective result of the experiment, the experiment should be operated under the same environment and condition. Through these experiments, data on the chroma, hue and luminance preferred by people can be achieved, accounting for factors such as race.

[0026] Table 1 is experimental data according to a Calibrated CRT-Display and an sRGBd viewing condition of an ITU-R (ITU Radio communication Sector) BT709 YcbCr Coding.

Table 1

	Y	Cb	Cr	C	H
Ideal skin color	038 ~ 0.7	-0.12 ~ -0.05	0.05 ~ 0.1	0.078 ~0.153	123°~152°
Color skin of real image	0.2 ~ 0.95	- 0.2 ~ 0	0.03 ~ 0.22	0 ~ 0.3	90°~ 165°
Area of preferred color skin	0.35 ~ 0.64	- 0.12 ~ - 0.03	0.07 ~ 0.14	0.1~0.7	100°~138°
Average (m)	0.51	- 0.074	0.098	0.124	126°
Average deflection	±0.082	±0.021	±0.0128	±0.0185	±8°
Statistical range($\pm\delta$)	0.427 ~0.592	- 0.095 ~ - 0.053	0.0856 ~ 0.11	0.105 ~ 0.143	118°~ 134°
Statistical range ($\pm 2\delta$)	0.35 ~ 0.673	- 0.116 ~ - 0.032	0.073 ~ 0.124	0.088 ~ 0.16	110°~ 142°

[0027] Referring to Table 1, the skin tone that is preferred by people is almost the same with the ideal skin tone. However, when the preferred skin tone is compared with the statistical range using 2 δ, the chroma is increased by 0.01, and the hue is moved by 10° in the direction of red.

[0028] FIGs. 4 and 5 are views showing the area of skin tone preferred by people based on Table 1, which is expressed in a YCbCr color space. FIG. 4 shows the area on an Cb-Cr plane, and FIG. 5 shows the area on a Y-Cb plane. For reference, the CbCr color space can be expressed as a YCH color space as a polar coordinate such as using the following mathematical expression 1.

Mathematical Expression 1

$$C = \sqrt{Cb^2 + Cr^2}$$

$$H = \tan^{-1}\frac{Cb}{Cr}$$

[0029] Therefore, when the values of Y, Cb, Cr, C and H are as given in Table 1, areas of FIG. 4 or FIG. 5 can be drawn. In FIGs. 4 and 5, the arrow adjacent to the area shows mapping of the values around the area into the area. In other words, the color can be compensated by mapping the color around the area of the skin tone preferred by people into the area.

[0030] FIG. 6 is a graph showing a hue deflection function for calculating a hue deflection. The axis X is the hue value and the axis T is the hue deflection ΔH with respect to each color value. In FIG. 6, m is an average value, r_{min} is a minimum value of skin tone range of a real image, and r_{max} is a maximum value of skin tone range of a real image. When the color value is within the range of m-δ, m+δ, it is the color value of the area of the skin tone preferred by people and there is no need to compensate the color. Accordingly, the hue deflection ΔH is zero.

[0031] When the hue value is less than $m-\delta$, it is the value that grows distant from the area of the skin tone preferred by people. Thus, the hue deflection ΔH should be increased. A maximum value of the hue deflection ΔH is H0, and this value is selected from values between δ and 2δ. Conversely, when the hue value is less than $m-2\delta$, the hue deflection ΔH is reduced. As described, the hue deflection ΔH is reduced because the color value that is less than $m-2\delta$ and is very likely not to be a skin tone. In other words, the compensation is performed within the range of color that is assumed as the skin tone.

[0032] When the hue value is greater than $m+2\delta$ is the same as above. Yet, the color deflection ΔH is a negative (-) value to reduce the hue value in this case. H1, the minimum value of the color deflection ΔH, is selected from the range between -2δ and $-\delta$.

[0033] A hue deflection function for calculating the hue deflection based on an input hue signal can be obtained using the above method, and the chroma deflection and the luminance deflection are calculated applying the same method.

[0034] Referring back to the flow chart in FIGS. 2 and 3, the skin tone mapping function generation unit 140 compensates the original chroma signal, the hue signal and the luminance signal by using the chroma deflection, the hue deflection and the luminance deflection calculated from the chroma deflection function generation unit 110, hue deflection function generation unit 120 and luminance deflection function generation unit 130 (S220). The method of compensation used by the skin tone mapping function generation unit 140 is to sum the calculated chroma deflection with the original chroma signal, the calculated luminance deflection with the original hue signal, and the calculated luminance signal with the original luminance signal. This can be expressed as the following mathematical expression.

Mathematical Expression 2

$$(Y,C,H)_{out} = (Y + \Delta Y(Y), C + \Delta C(C), H + \Delta H(H))$$

[0035] As described so far, a distorted color can be compensated by compensating the chroma signal, the hue signal and the luminance signal existed around a certain area like the skin tone based on a calculated chroma deflection, hue deflection and luminance deflection.

[0036] The case of the skin tone compensation has been described in the preferred embodiment of the present invention. Yet, the method of calculating color data preferred by people can be used with respect to any color, and after that calculating chroma deflection, hue deflection and luminance deflection are based on the color data. Moreover, while color properties of chroma, hue, and luminance are discussed by way of example, it is understood that additional properties can be similarly compensated in a multidimensional color space.

[0037] According to the present invention, when a color that is sensitive to the eyes of people in an input image is so distorted as to be unsuitable for photographing because of a transmission flaw or various external lights, the distorted color can be compensated to one preferred by people.

[0038] While not required in all aspects, it is understood that the method of the present invention can be implemented using computer software, including firmware, readable by a computer.

[0039] Although various embodiments and aspects of the present invention have been described, it will be understood by those skilled in the art that the present invention should not be limited to the described embodiments, but various exchanges and modifications can be made within the spirit and the scope of the present invention. Accordingly, the scope of the present invention is not limited within the described range but is instead defined by the following claims and the equivalents thereof.